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Aspects of the roughing process by milling with the milling heads with removable plates on NC lathe of the worms

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Abstract

In this paper there are presented aspects regarding roughing process of cylindrical worms with large module on NC turning and milling center. Conventionally, worm of worm gears have been made on dedicated machines using dedicated tools. These machines are for mass production of worm gear. Small companies cannot invest in these machines especially if their core product is something other than gear manufacture. For the manufacture of worms are not required special tools, all that is required in the roughing process on the NC Lathes are standard tools such as milling heads with removable plates or mono-block frontal-cylindrical milling tools. From economic reasons we insist on roughing research using milling heads with removable plates. The study highlights the fact that it can use in the roughing process of the worms on NC lathe the milling tools with removable plates the cost in this case is less than if we use in roughing process milling tools from mono-block carbide. Important is the Mills positioning in relation to the middle goal of the worm. Determination of the position of the milling head is done based on a computation already submitted in a previous work, determining the parameters of milling is done taking into account the manufacturer's recommendations and testing tools. The tool path has been chosen so that milling to make in advance and counter advance sense, so that we can obtain the tool path for the best sustainability tool.

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Keywords: worm; milling heads with removable plates; roughing; tool path; CNC machine;

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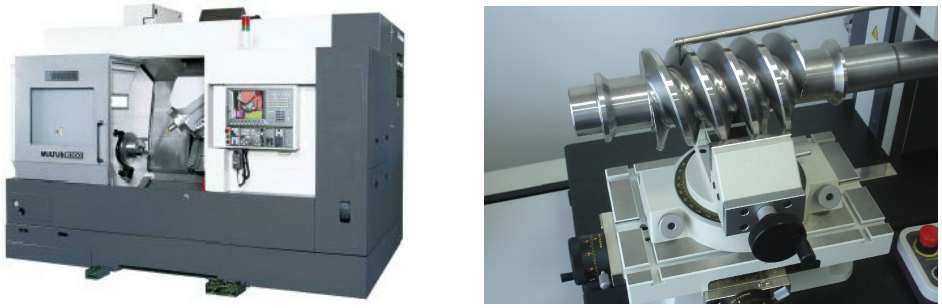
1. Introduction

According to STAS 6845-82 standard, the cylindrical worms are classified as: ZA – worm with a straight-line tooth profile in axial section, ZN – worm with a straight-line tooth profile in normal tooth section, ZE – worm with a straight-line tooth profile in a plane tangent to the main cylinder, ZK – profile formed by a cone ground using a wheel and/or shank tool.

The steps that the worms are executed are [1]:

- Roughing,
- Semi-finishing,
- Finishing.

Due to the high volume of material to be removed including roughing is a challenge. In the case of processing worms through new technology on NC lathes [2], [3], [4] the equipment used in the processing of worms is OKUMA MULTUS B300 (Fig. 1.). Turning and milling Centre has 5 axles.



(a) (b)

Fig. 1.(a) Turning and milling Centre OKUMA MULTUS B300[5] (b) Studied worm

Nieszporek presented the formation of worm surfaces with a spherical finger-type cutter in many passes by the Lace Cut method using modern CNC machine tools which enable the development of worm gear technologies [6]. In [7] proposed a method for processing cavex worm on CNC machine tools using spherical finger-type cutter.

Abdullah proposed a method of modeling in which to avoid the technological difficulties relevant to the application of special cutting tools for machining such gear sets, a rigid incongruent generating pair consisting of a standard hob and toroid tool has been developed for processing the concave worm profile [8].

Ying presented that under the premise that lack of special equipment, we can use generating method to transform CNC machine tools and receive the desired results [9].

In [10] Li Yang was presented a new rough turning method based on discretization of the spiral surfaces of the worm. In [11] was presented a milling method based on discretization of the spiral surfaces used on a CNC turning center with a cylindrical end milling cutter.

Gyenge proposed to utilize at manufacturing of complex surfaces of special worms the processing of hardened steel with ultra-precision turning [12].

2. The studied worm and the tools used in the roughing process

The studied worm is used to winch of the TAF which are produced at S.C. Irum S.A. Worm (Fig. 1. (b)) is cylindrical Archimedean with module m=10, diametrical coefficient q=7.6 with two beginnings, the sense of the winding right. Selected tools for roughing have a diameter of 12 mm. The material used for the processing of the worm is OLC 45 improved to 35 HRC.

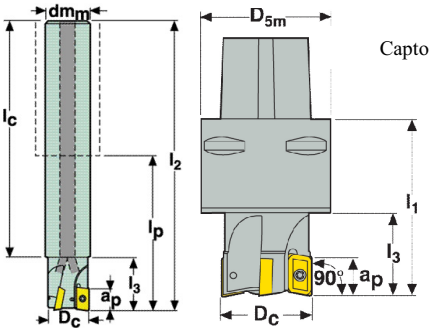
In [13] at the roughing of the goal were used to the roughing of the worm flanks frontal-cylindrical milling tools the mono-block carbides produced by EMUGE-FRANKEN, tool Code: 1987A.012, diameter 12 mm. Using parameters from (Table 1.) were processed 4 worms after that the tool can't be used thanks to the wear. Due to the cost of about 140 – 150 Euro tool, an attempt was made to reduce manufacturing costs by using the milling heads with removable plates. Once purchased the milling head, the price of the removable plates is about 7 Euro.

Table 1.Parameters of the milling

Cutting speed [m/min]	Revolution of the milling tool rot/min]	Advance speed[mm/min]	Advance of the tooth[mm/tooth]
120	3200	1024	0.08

The milling head and removable plates chosen for the tests are produced by SECO. The milling head for these machining is type Micro Turbo, code R217.69-1612.0-09-1AN, whose features can be seen in (Fig. 2.).

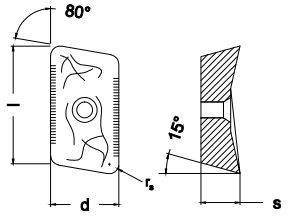
Micro Turbo 217.69-09



Part No.	Dimensions in mm									weight	Removable plates	
	D_c	dm_m	D_{5m}	l_1	l_2	l_p	l_3	l_c	a_p		No.	Type
R217.69 – 1612.0-09-1AN	12	16	-	-	135	87	22	105	8	0.2	1	XO..0903

Fig. 2. Chosen milling head [14]

For the first trials was selected removable plate code: XOMX 090308TR-M08, MP2500, whose features can be seen in (Fig. 3.):



Tolerances(±mm)

	d	s
XOMX	0,03	0,05

Size	Dimensions in mm		
	l	d	S
0903	9,9-10,8	6,35	3,21-3,65

Part No.	r_s	Cutting rake	G				R	A		D	E	S					
			MP1500	MP2500	MP3000	MH1000	MM4500	MK1500	MK2000	MK3000	MS2500	T25M	T350M	F15M	F25M	F40M
XOMX 090308TR-M08	0.8	16°	X	X	X		X	X	X				X			X
XOMX 090308TR-M06	0.8	24°	X	X	X		X	X	X		X	X	X		X	X

Fig. 3. The choice of removable plate [14]

For a longer service life of the plates, the company SECO recommends the milling in sense of advance. In Fig. 4. is presented the milling head with the first removable plate.

Fig. 4. The milling head with the first removable plate

Due to unsatisfactory results obtained using the first type of removable plate used for processing, was used another type of removable plate XOMX 090308TR-M06, F40M.

3. Route of the tool and the positioning of the milling tool

Determination of tool path was made through an iterative process, initially it was chosen roughing of the channel in three passages for each start. The effect was unacceptable wear and vibration leading to five passages for each start (Fig. 5.).

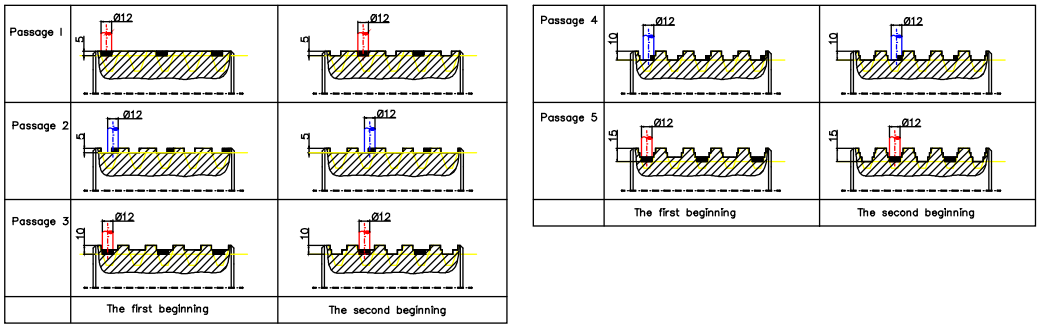


Fig. 5. The route of the tool

Roughing process of the worm can be done with the milling tools with removable plates or milling tools from mono-block carbide. Because the milling is made in the sense of the advance (at using milling heads), the milling head rotates clockwise, moves from right to left and the half product rotates clockwise.

The tool position is done using coordinate transformations [16], [17] transposed in a program designed specifically for this [15], so that a result of processing remain the desired addition of processing. For the tool diameter of 12 mm and connections radius of 0.8 mm, position of the tool towards to the middle of the goal for each crossing is shown in (Fig. 6).

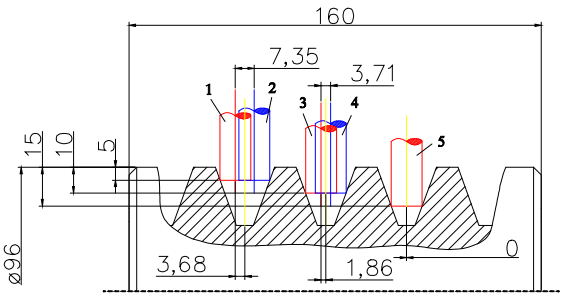


Fig. 6. The position of the tool[15]

4. Roughing the flanks worm and cutting parameters

The first attempt was made with the parameters calculated according to the recommendations received from the company SECO who are presented in (Table 2.) Due to the high vibration arising to roughing it was concluded that the system must be stiffened and for this it passed to shortening the head milling with 30 mm, and also has changed cutting regime controls changing the half product revolution, so by default it was shrunk down the advance on the tooth. The new machining parameters are presented in (Table 2.(b).).

Table 2.Parameters of the milling

	(a)Recommended parameters				(b)The experimental parameters			
Crossing/ started	Rotation of the cutter (n) [rot/min]	Cutting speed (v_c) [m/min]	Advance speed (v_f) [mm/min]	Advance on the tooth(f_z) [mm/tooth]	Rotation of the cutter (n) [rot/min]	Cutting speed (v_c) [m/min]	Advance speed (v_f) [mm/min]	Advance on the tooth(f_z) [mm/tooth]
1/1	4000	150.80	332.87	0.08	4000	150.80	277.39	0.07
1/2	4000	150.80	332.87	0.08	4000	150.80	277.39	0.07
2/1	4000	150.80	443.82	0.11	4000	150.80	388.34	0.10
2/2	4000	150.80	443.82	0.11	4000	150.80	388.34	0.10
3/1	4000	150.80	320.96	0.08	4000	150.80	271.58	0.07
3/2	4000	150.80	320.96	0.08	4000	150.80	271.58	0.07
4/1	4000	150.80	444.41	0.11	4000	150.80	395.03	0.10
4/2	4000	150.80	444.41	0.11	4000	150.80	395.03	0.10
5/1	4000	150.80	324.99	0.08	4000	150.80	281.66	0.07
5/2	4000	150.80	324.99	0.08	4000	150.80	281.66	0.07

Using these parameters, it was switched to the roughing of the worm. At the third crossing first started, after processing the cutting edge of removable plate was nicked, was changed cutting edge of the plate, continued working and going out of the fifth crossing, the second beginning, the second cutting edge was nicked (Fig. 7).

Fig. 7. The removable plates XOMX 090308TR-M08, MP2500 after roughing

Due to the low durability of the removable plate in the processing of roughing, by choosing a new plate that has been passed to a new process using the same parameters as in previous processing, the milling had was shortened with a further 15 mm. The code of removable plate is XOMX 090308TR-ME06, F40M (Fig. 3.), with the rake angle of 24 °. The major difference between the two types of plates is actually quality of removable plate.

First quality of the removable plate chosen was MP2500 recommended for milling steel and stainless steel of small or medium difficulty with or without liquid cooling. The second chosen quality F40M, is recommended by the manufacturer when there is risk of vibrations (in the case of this processing vibrations are high) and when it is used liquid of cooling.

In this case, the plate being much more endurance to vibrations, was roughing one worm and half with one cutting edge. Compared, the length of the canal milled with the two plates is present in (Table 3.)

Table 3.The length of the milling canal

Tipe of removable plates	The length of the milling canal [m]
XOMX 090308TR-M08, MP2500	3.2
XOMX 090308TR-M06, F40M,	9.6

To calculate the length of the path tool we shall take into account the cylinder propeller tie in the plane (Fig. 8.).

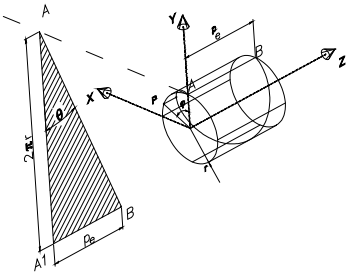


Fig. 8. Cylindrical propeller tie in plane

$$AB = \sqrt{(2\pi r)^2 + P_E{}^2} \tag{1}$$

$$AB_1 = \frac{l * AB}{P_E} \tag{2}$$

Where:

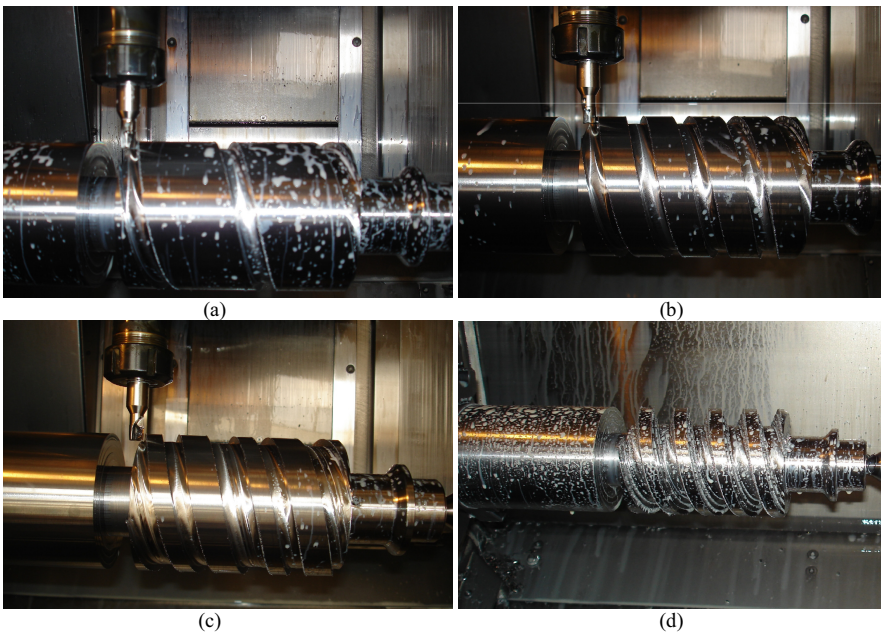
AB - the length of the tool path for a step;

AB_1 - the length of the tool path of helical canal on all length of the worm (l);

P_E - the propeller step;

r - radius of the cylinder which wrapped the propeller.

In (Fig. 9) are presented pictures of roughing process, in (a) is the first pass for the first start of the worm, in (b)



(a) (b)

(c) (d)

Fig. 9. Pictures in different moments of processing

first pass for second started when was milling a helical channel. In (c) is presented image for the second pass for the first start of the worm when was milling a helical wall. At the milling of the channel vibrations were lower than at the milling of the wall. In (d) shall be presented to the worm after roughing process.

5. Conclusions

Experiments conducted and presented in the paper have resulted in obtaining significant information about the possibilities of achieving the roughing process on CNC machine tools, these items can be presented synthetically in the form of the following conclusions: rough processing of the worms on machine tool CNC in small series can be made by milling using mono-block frontal-cylindrical milling tools or milling heads with removable plates; in the case of the worm roughing using milling heads with removable plates the cost are much smaller; the disadvantage of using milling procedures with removable plates is the longer duration as compared to mono-block milling; with the help of mono-block frontal-cylindrical milling tools or milling heads with removable plates can be process materials with a hardness of up to 55 HB.

Acknowledgment

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